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CHEMISTRY

MADE EASY,

FOR THE

USE OF FARMERS.

BY J. TOPHAM, M.A.

NEW-YORK:
C. M. SAXTON, AGRICULTURAL BOOK PUBLISHER,
No. 123 Fulton Street.
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PREFACE TO FIRST EDITION.

An opinion having been expressed by an individual of great talent, sound judgment, and elevated station in society, and coincided in by several gentlemen who were present at the time it was delivered, that were an *inexpensive*, *short*, *and easy-to-be-understood* treatise written, showing in what manner a knowledge of Chemistry is useful to the business of agriculture, wherein its terms are explained, so as to be comprehended by persons unacquainted with the language of science, and an insight given into its general modes of action, as an inducement to further inquiry, an essential service would be performed for the agricultural interest of the country; and that opinion being accompanied with a request, that the composer of this treatise would attempt to furnish such a desideratum, he, after mature deliberation, consented to accede to their wishes, and herewith submits

the result to the candid consideration of agriculturists. That two of the conditions have been accomplished, will, he thinks, be generally admitted; and if he shall learn that the third has been fulfilled to the satisfaction of his readers, the highest gratification will be afforded to the feelings of its author.

Many of the statements recorded in the following pages are founded upon the authority of *Liebig*, whose writings on Organic Chemistry may be consulted with advantage, and will be read with pleasure by every admirer of scientific research and inductive reasoning.

PREFACE TO SECOND EDITION.

In bringing out this second edition of the accompanying treatise, the author embraces the opportunity to return his most grateful acknowledgments to the numerous correspondents who have favoured him with their suggestions; but especially his thanks are due to the agriculturists and gentlemen, who have testified their high approbation of his efforts to render Chemistry intelligible to farmers, by purchasing copies for distribution among their respective friends.

In this present edition, which is considerably enlarged, his friends will discover that their kind attention has been duly appreciated, and he ventures to hope, that his attempt to please and instruct has not been in vain, among the class of readers for whom his little volume was designed and written.

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OPINIONS OF THE PRESS.

This little work is worth reading, as an introduction to a serious inquiry into Chemical Phenomena.—*Gardner's Chron.*

No farmer should be without this little inexpensive book, the perusal of which will guide him to the knowledge it is so important he should acquire. It is written in so clear and plain a style, as to be intelligible to the meanest capacity, while the various Chemical combinations, the phenomena of the growth and nourishment of plants, the nature of soils, &c., are explained in the most familiar manner.—*Worcestershire Chronicle.*

The extracts we have given are worth the entire cost of the book; but when we add, that it has hundreds of similar pleasantly and clearly told illustrations, of the usefulness of Chemistry to the farmer, we think we have said quite enough to induce all who think our judgment worth a rush, to buy it.—*Worcester Herald.*

We have much pleasure in recommending to the notice of our agricultural readers, a useful and compendious work, from the pen of the Rev. J. Topham, entitled "Chemistry made Easy." They will find, in this little brochure, many valuable hints laid before them, in the most simple and intelligible form.—*Worcester Guardian.*

A short but apparently useful treatise, on that very interesting subject, the application of Chemistry to agricultural purposes. It is written in easy and familiar language.—*Athenæum.*

This is indeed, although on a minor scale, a very complete farmers' vade mecum of practical Chemistry. The language employed is simple, and the illustrations are so clear as to become easily understood by any ordinary capacity.—*Farmers' Journal.*

CHEMISTRY MADE EASY.

"All nature is but art, unknown to thee;
All chance, direction, which thou canst not see."

In the age in which we live, when Mechanics' Institutes, Literary and Scientific Societies, and Schools of Design, exist in almost every city and town, professedly established for imparting to individuals, of the middle and working classes of the community, information which may be made available, in the respective employments and business in which they are engaged; will the farmer refuse to exert himself, in the movement that is around him, and be content to remain stationary, while his humbler neighbours are active in the pursuit of knowledge, and in the improvement of their condition, by means of the

substantial advantages which are known to accompany it?

His position in the social body is one of respectability, responsibility, and of honour; and if he is desirous of fulfilling, efficiently, the duties which his station calls upon him to discharge, and of realizing an independence from the profits of his profession, he must adapt his system of management to an improved condition of rural economy, and regulate his farm-business by the rules which practice with science will teach him.

It is the remark of the wise man, that "the hand of the diligent maketh rich:" and daily experience shows us, how greatly exercise, both of body and of mind, contributes to the formation of human happiness, and of health. But when the hand of diligence is directed by the head of wisdom, and the operations of agriculture, or any art, are regularly conducted upon well-ascertained principles, then, not only will an immense saving of capital and of labour be

effected, by the persons who so act, but in watching the development of the system they shall have adopted, and in observing how all things harmoniously work together for good, when sufficiently supplied with the materials, which their respective circumstances require, a mental gratification will be experienced, which no sensual pleasure can equal, and if money is to be made, such individuals will be most likely to realize it.

Will then, I repeat, the farmer be content to remain stationary, while his humbler neighbours are acquiring knowledge? Will he obstinately despise the aid of a science, by whose instrumentality his operations may be conducted, with the surest prospect of profit? This science is Chemistry; and to the agriculturists it would seem to be indispensable.

The earth, the air, and water, are the three grand agents by which he works. To become acquainted with the elementary constituents of these several objects; to know something respect-

ing the influences they exert over the bodies with which they come into contact, and the results thereby produced, should, consequently, be the first aim of his professional ambition. What is necessary for all practical purposes, may easily be learnt, by a careful attention to a few simple facts, principles, and rules, which experimentalists shall have ascertained, established, and recorded; and in the occupation in which he shall engage himself, he will find no reason for regretting the time he shall give up, or the trifling pecuniary outlay he may be required to incur.

Transformations will present themselves, on every side, to his astonished view, and in the vast laboratory of nature, he will discover that nothing becomes useless, nothing is destroyed. The dissolution and apparent annihilation of matter, is but an operation, in the wonder-working hand of the Creator, subservient to the great purpose of re-production; and the universe teems

at this hour, with the elements necessary to the formation of substances, requisite for the support of animal and vegetable existence, and for the well-being and happiness of animated creation, as in the infancy of the world, when "God looked upon every thing that he had made, and behold it was very good."

The cultivation of such a science will, therefore, be beneficial to his interests, both as respects his mind, his fortune, and his character. It will expand his ideas. It will enlarge his knowledge. It will teach him how to economize labour and pecuniary outlay: and should his soul be susceptible of holy feelings and sublime impressions, it will raise his thoughts from the things that are seen and made, to the contemplation of the Great Being who created them. It will show him,

"Tongues in trees, books in the running brooks,
Sermons in stones, and good in every thing."

In order to the accurate acquisition of useful

knowledge, it is necessary that the mind of the inquirer should be entirely divested of early imbibed prejudices, and popular errors; as that there are four elements—Earth, Air, Fire, and Water; such substances only being regarded as elementary bodies, by the scientific, which the skill of man has been able to separate or to reduce to but one constituent; of which simple or elementary principles, the number, at the present period, amounts to nearly sixty.

It is but a very few years ago, that insects and flies were supposed to owe their origin to decomposed mud and putrid flesh, stones to grow, and those green rings, which are frequently to be observed in pastures, to be caused by the mysterious agency of fairy power. But now, by the introduction of a more enlightened philosophy, the operations of nature have become much better understood than formerly, and the enigmas, which perplexed our forefathers, have been satisfactorily explained.

To an uninstructed individual, whose reasoning and perceptive faculties are but very rarely brought into activity, in the exercise of his calling,

> "The primrose, by the river's brim,
> A simple primrose is to him,
> And it is nothing more."

Give him, however, the opportunity of cultivating his understanding, by means of books, lectures, and the various institutions, which the age abundantly affords, and he will quickly regard it under a different aspect, and dwell, with delighted admiration, on the variety of its parts, the intricacy of its construction, the delicacy of its arrangements, and the beautiful adaptation of its several circumstances, to the purposes they are designed to accomplish. In his enlarged view of nature, he now contemplates it, as a living, breathing, finely-organized structure, possessing organs of respiration, circulation, and re-production; together with an apparatus, per-

fectly appointed, for the conversion of the food it derives from the earth and atmosphere, into the leaves, flowers, and seeds, which it progressively exhibits: and consequently, not less worthy of his admiration than the animals which graze around it.

The hitherto dormant powers of his mind being once awakened, and a spirit of inquiry pleasingly excited, he is induced to institute an examination into the reasons why the business by which he lives hath been conducted by a particular uniform system; and, (if a farmer,) perceiving its incompleteness, he resolves upon a change; and the question that suggests itself to his consideration is, what is the soundest, and, therefore, probably, the most profitable method I can adopt, successfully to accomplish the object I have in view? To which the answer is, work with those implements, which mechanics shall have improved; and in conformity with those

rules, and modes of action, which Chemistry will teach you.

Observation and experience will, indeed, instruct men in many things which may be advantageously put into practice, in the ordinary operations of a farm; but it is only by being acquainted with the laws and methods by which nature performs her work, and by conducting their business with a knowledge of the constituents of the various materials, which they are necessitated to employ, and by means of a system, calculated to produce certain results, that their chances of incurring disappointment and pecuniary loss are incalculably diminished; and they are enabled to account for circumstances, should their plans sometimes fail, and their crops, in the time of harvest, prove defective.

Experience will inform them, in which pastures on their estates, or by what description of food, oxen and sheep can be readiest fed, and

prepared for market; but it is Chemistry which will show them, that the flesh, which covers their bones, is to be found ready formed, as to its constituents, in the herbage they consume; point out the plants, the seeds, and roots, most rich in the qualities requisite to produce the result desired; and enumerate the various properties which the soil must possess, to afford the plants the proper nourishment which their circumstances shall require, in order fully to complete their germination, and mature their seeds; and thus, during their growth, and when ripe, be made to communicate their virtues to the respective animals which shall feed upon them.

It is Chemistry which will teach them that the seed of wheat is, in a great measure, constituted of three elementary bodies, which, after being imbibed from the soil and atmosphere, are converted into a sweet fluid, (sugar,) which fills the vessels of the green stalk that supports the ear; and are, in that ear, afterwards transformed,

by a slight alteration of the quantity of two of the elements spoken of, into the starch or farina, which, more especially, renders the corn valuable; and that, to afford the plant the means of most efficiently carrying on its operations and transformations, it must be supplied with those properties, whereof the soil shall be deficient, by a judicious application of such materials as are known to possess the qualities of which it is in want, and in a state to communicate them, when its circumstances may require them.

Every agriculturist being acquainted with the well-established fact, that grasses, cut before they are fully ripe, are generally much more valuable as food to cattle, than afterwards, on account of the sweet juices with which they generally abound, I am somewhat surprised that Indian corn, (which, from its seldom maturing its seeds, in the climate of Britain, is rarely to be seen in the fields of this country,) is not most extensively cultivated, as a green crop,

for that especial purpose. For while in this condition, it is superabundant in saccharine fluids, important to the formation of animal fat; and, consequently, worthy of greater attention from farmers, than it appears, hitherto, to have received.

Our clever calculating friends, on the other side of the Atlantic, are, however, wide awake to its advantages and usefulness, and grow it abundantly, not only for the sake of the vast yield of seed which it affords, but also as a profitable nutriment for their herds; and who, in many parts, after they have crushed and pressed the stalks, manufacture the liquor extracted into very excellent sugar.

The vast importance of understanding the nature and properties of manures being alluded to, in a foregoing page, it may not be here out of place to say a few words, on an expensive foreign production, reported to be the excrement of certain sea-birds, and recently introduced to the

notice of agriculturists, under the name of Guano, and in the purchasing of which, individuals may be very seriously taken in, if they are unable to distinguish an adulterated manufacture from the genuine article, which the high price of the material will induce unprincipled persons to imitate. By procuring it from the warehouses of respectable merchants, this risk will, in a great measure, be avoided. Of its astonishing powers of promoting vegetation, there can be no dispute, when it shall be applied to the land, before it has been long exposed to the moisture of the atmosphere, and is unmixed with substances which deteriorate its value.

But although it may be applied to the soil, both fresh and genuine, still various circumstances must be attended to, if the advantages it is capable of rendering vegetation are to be realized, from its employment. The quality of the land on which it is about to be tried, ought, in the first place, to be carefully ascertained, and also

the description of the manure with which it may recently have been dressed. For if it should be commingled with substances, for which its constituents possess an affinity, (as lime or vegetable-ashes,) you will prematurely disengage the properties which the plants shall require, and thus, eventually, lose both your manure and your crop.

As all vegetables imbibe their nourishment while it is in a state of solution, moisture must therefore be present to effect this condition, or the guano will remain inert, until a shower of rain shall descend, or artificial watering shall be administered. Indeed it is highly probable, that from inattention to these and other objects, necessary to the proper decomposition of the compound, failures frequently have occurred, and the manure has been thus unfairly condemned; whereas, had the state of the weather, as to wind, rain, sunshine, or clouds, and also the nature of the soil on which it was used, been

correctly noticed and reported, then proper allowances would have been made, according to the circumstances of the case, and the experiment received its proportionate value.

The foregoing remarks are equally applicable to nitrate of soda, or sulphate of ammonia, of potass, and other compounds of a similar character, which, if purchased without knowledge, and used without judgment, will most assuredly prove expensive, and, in the end, cause disappointment.

This knowledge, I again repeat, is to be acquired from a slender acquaintance with the common principles of Chemistry, and may be obtained, for most practicable purposes in husbandry, by dedicating a few spare hours in every week to reading, experiments, observation, and reflection.

It is, however, absolutely necessary to the efficiency of manures, whether artificial or otherwise, that the fields to which they shall be applied, shall have been carefully drained. For although

a running stream, suffered periodically to irrigate a portion of a farm, is one of the most active fertilizers of the soil with which we are acquainted, stagnant water, either on the surface, or in contact with the roots of plants, is a deadly poison; such river water or running stream, besides holding mineral and saline matter, both in suspension and solution, abounds also in animalculæ, called *infusoria*, whose minute bodies, by infiltration of the fluid, become incorporated with the land, and, on decomposition, afford ammonia to the plants which cover its surface, and thus increase its productiveness.

Having already premised, in a former page, that plants principally derive their solids and other properties, from the soil in which they grow; and are rich in cattle-nourishment, or in seed-produce, in proportion as they shall be supplied with food, necessary for the full development of their organization and vigorous health; it is the interest of the agriculturist, to

learn what are the conditions that are necessary to the profitable cultivation of his farm, and to adapt these to his purposes, as extensively as circumstances will permit. For it is well known, to men of science, that samples of wheat, (for example,) which are alike to all outward appearance, and have been produced from the same seed, sown upon different descriptions of land, are found widely to vary in the qualities which most especially constitute its worth; the one being abundant in the yield of flour, the other exuberant in bran.

In a farm, of any considerable extent, the fields will be different, as to the aspect in which they lie, and the nature of the soil of which they are composed. Hills, and valleys, and plains, diversify the face of the country; and, by the wise arrangement in which they are disposed, contribute to render it both beautiful and fruitful.

Some localities will be rich in decayed vegetable-matter, marl, clay, lime, and certain agents

called salts; which, although invisible to the eye, and imperceptible to the taste, perform a most important service in the process of rural economy. Others will possess clay and sand in superabundance, and be defective in vegetable matter and marl; while a third shall be formed altogether of sand and gravel.

The grand desideratum, therefore, of the agriculturist is, to know how to commingle these respective ingredients, so that his lands shall possess the qualities which are likely to afford the greatest supply of nourishment, for raising to perfect maturity the crops, arising from the seeds which shall have been sown between their furrows, and which, to a considerable degree, may be accomplished by the transposition of certain descriptions of earth, from localities wherein they are abundant, to the fields in which they are not present, and wanted.

For example;—if wheat be sown upon a soil, composed, in a great measure, of decayed

vegetation, (as peat-earth,) the plant will flourish in a most extraordinary manner, for a period, and, by its luxuriant appearance, promise the farmer an abundant return in harvest; and could it but fortunately sustain the exuberance of its germination, no doubt the produce would be equal to his fondest anticipations. But to insure this most desirable result, it is necessary that the stalk should be incased in a cylinder of flint, and if sand is not present, and an alkali, to aid in its solution, the plant will bend and fall under the load, which its well-gorged organs shall have accumulated, and the cultivator be disappointed of the rich remuneration it promised him.

The most careless observer of the various herbage which clothes with verdure the hills, the valleys, and plains of the country in which he lives, will not have failed to have remarked that plants which are common to sandy lands, are not generally to be found growing on marly ground; but that loamy, chalky, and gravelly soils, have

each their peculiar and appropriate vegetation ; and it is an ascertained fact, that when such plants are removed to soils of a different nature to that on which they flourish, they speedily become stunted in their growth, and, in a short time, droop and disappear.

The object of the farmer should therefore be, to cultivate such species of plants as experience shall have shown him the land will naturally vigorously support, or to add to it those vegetable, saline, or mineral substances, which are known to be necessary to their healthy existence, wherever such shall be known to be wanting. Thus will he reduce his system of husbandry to a similar standard of accuracy, to that which most of the arts have already attained, and also be able to render productive and profitable, lands which had hitherto been considered as comparatively barren and worthless.

If attention is to be given to the nature and management of the soils, in which grain, pulse,

and tuberous-rooted vegetables, are to be cultivated, no less diligence is to be used, in ascertaining the merits of that, on which green-crops are to be raised, for the support or feed of cattle. For in the fibres, juices, seeds, and tubers of these, respectively, exist the very flesh and blood which show themselves, afterwards, in the bodies of the horses, oxen, or sheep, which formerly pastured on them; so that by supplying his stock with certain descriptions of vegetable provender, and in different stages of maturity, their owner will be enabled to render them sinewy or plump, as the circumstances may require, or his fancy may lead him.

What those materials are, which produce such results, have been ascertained by chemists, and separated from the respective herbage and seeds in which they are elaborated and exist. Their nature and properties will be attempted to be explained in another part of this treatise, and which, if at any time deficient in the food that is

afforded, the cattle will be stinted in size, and in their appearance, unhealthy.

Fat, be it however remembered, is not a necessary condition of vitality, but a redundant material, extracted from food which animals consume, and deposited in various parts of their bodies, after the wants of nature shall have been satisfied, as far as respects the re-production of those portions of their organization, which are constantly subject to flux and change; and is principally constituted of an element termed CARBON.

The food of animals consisting chiefly of fibrinous and carbonaceous materials, after being received into the system, the latter unites with that element of the air which, inspired, and also taken up in the saliva, generates heat, producing the animal heat of the body; whilst the former is deposited as flesh; which heat, if rapidly carried off either through violent exercise, or by chilling blasts of wind, will be supplied from the

carbon which this oily substance will afford; from which circumstance, we learn the reason why, in the preparation of cattle for the butcher, abundance of suitable provender, quietness, and warmth, are essentially necessary to a huge formation of this much-prized desideratum; and also why mountain-pastured sheep, hares, and other animals, which are compelled to activity in a state of nature, never treat us with a taste of their fat; and should the reader agree with the facetious gentleman, who asserted that he

"Who feeds fat oxen should himself be fat,"

I have no doubt he might, (with healthy organs to aid him,) by adopting a similar course of proceeding to that pointed out, in the foregoing lines, effectually accomplish the object of his ambition.

The bodies of cattle and of mankind may therefore be regarded as a species of natural stove, the heat of which becomes raised or lowered, according as the circulation of the blood, through the lungs, is quickened or retarded, by immoderate

exercise or otherwise; the fuel being supplied from the carbon of the food, and which, if not present in the blood, in sufficient quantities to combine with the oxygen of the air, will be abstracted from the fat, or from solid portions of the body, of importance to health and life.

Of late years, much has been spoken and written, upon the propriety of giving common salt to cattle, and of employing it largely in the cultivation of land; but of its virtues, in the one case, and of its advantages in the other, I, with submission, think that very great doubt may be entertained. For except in protecting the young plant from the ravages of slugs and wire-worms, and from the property it possesses of abstracting moisture from the atmosphere, (and in dry seasons being thus slightly useful to plants growing on light and sandy soils,) it can be only of small service, or contribute but little to the process of vegetation; and although one of the ingredients of which it is composed, (soda,) is

necessary to the perfection of animal life, yet it has been ascertained, by experiments, that when copiously given to cattle, (if not absolutely detrimental to their health,) is a positive preventive of their *feeding*; and should, consequently, always be used sparingly, and with discretion, by the persons who may be induced to employ it.

Though such is my opinion, yet it is only proper to state, that agriculturists, of experience and credit, have asserted that common salt, well incorporated with quick lime, (in the proportion of two parts of the latter to one of the former substance,) and copiously spread upon soils in the spring, has materially increased the crops, both of grass and of corn; and that these minerals, so incorporated and sprinkled over layers of weeds, collected into a heap, have speedily converted the same into a most fertilizing compost.

It is a fact, well known to every cultivator of the land, and breeder of cattle, that wherever

his stock shall have deposited their urine, in the pastures in which they have grazed, vigorous clumps of dark green herbage speedily distinguish the spot, and wave their streaming verdure high above the grass which grows around them. Which circumstances should suggest to him the propriety of devising means of preventing, as much as possible, the escape of this fertilizing friend of farmers, from his dung-heaps, and his fold-yards; and cause him to husband, carefully, what shall be collected in the slop-pail of his chamber-maid.

Indeed, were subterranean tanks constructed under those private retiring places, provided in the neighbourhood of markets, manufactories, poor-law unions, railway stations, and schools, much of the money, now expended in the purchase of guano, might be profitably saved, and one of the most potent and valuable manures accumulated at our very doors; and that which,

as yet, has never occurred, except in the imagination of the poet, who asserts,—

"A time there was, ere England's griefs began,
When every rood of ground maintained its man;"

by adopting the arrangement here recommended, and applying to the soil the material collected, may, in reality, hereafter be brought to pass.

For such, being diluted with pond-water, and distributed plentifully over meadow-land, from a proper machine, would quickly occasion an increase in the herbage, which liquor from the gas-works only would occasion, equal in amount, and which, where it can be procured from a place within a convenient distance for drawing, and purchased at a reasonable price, and applied to the land in *rainy weather*, will promptly manifest its astonishing virtues, and amply reward the person who shall use it.

It is not from his fold-yard and dwelling-house only, that things important to agriculture are permitted to run to waste, but in the morning,

when he visits his stables for the purpose of inspecting his horses, the master is often assailed, on his entrance, by a spirit (of hartshorn,) so energetic in its attack, as sensibly to affect both his nose and his eyes, and which, not unfrequently, exerts a baneful influence over the health and vision of the animals exposed to the action of its corrosive breath, but which, when laid under the turf, by the charm of the chemist, will richly benefit the soil wherein its decomposition is accomplished. But, as Mrs. Glasse informs her readers, they must first catch their hare, before they can cook and eat it, so must a snare be set for the spirit which we wish to render subservient to our views, before we can control it at our pleasure, or use it for our profit. This is to be done by presenting such matters to its notice as we may have heard are likely to attract its attention. Thus, if gypsum be at hand, and is placed in a roughly broken state, in a reservoir, under a grating, in the stalls in which the

animals stand, this object may be obtained, and the spirit entrapped. Or if such substance is not to be found upon the estate, then the same result may be secured, by spreading dried turf, pared and brought from the boggy portions of the farm, or burnt clay, beneath the straw which constitutes their bedding; and whilst a most invaluable manure will thus be collected, which was previously lost, the stable-atmosphere will be rendered sweet and salubrious, which had been disagreeable, noxious, and unhealthy, to the horses which inhaled it.

The page of history and our own observation inform us, that the brute creation, like their masters, are frequently subject to diseases, which have their origin in causes but very little understood; and are, consequently, sometimes beyond the power of human skill to cure or alleviate. Indeed it was observed in periods as remote as the plague of Athens and the siege of Troy, that pestilences, of direful character, first tried their

power upon animals, before they assailed the human family ;—

"With mules and dogs th' infection first began,
At last, the vengeful arrows fix'd on man ;"

and when we reflect upon the insidious manner in which fevers sometimes steal into our dwellings, and suddenly snatch from us the fond objects of our affections and hopes, it is not improbable that these mysterious destroyers of men and beasts may be caused by exhalations from the earth, or by invisible insects, hatched under peculiar states of the atmosphere, favourable to their production, or by malaria, occasioned by the rapid decomposition of vegetable-matter in sultry weather, (which we know occasions ague,) and consequently creatures which are necessitated to respire near the surface of the ground, whilst in the acquisition of their food, are likely to be the first to imbibe the poison, and by the effects produced on them, apprize us of the approach to-

wards our dwellings of a dangerous and destructive enemy.

Happily, however, chemistry has discovered an agent, which, in many cases, will crush the dreaded foe; and should one of your horses or your cattle be attacked with disease, its farther progress among your stock may generally be arrested, by placing in a saucer a small piece of common salt, and occasionally moistening it with about a tea-spoonful of oil of vitriol, by which simple proceeding, the remaining portion of your cattle will, most probably, be preserved from contagion and destruction, and your family not subjected to the distress which so melancholy an event would naturally occasion.

The rot in sheep, which is a disease similar to the typhus fever, in man, is known to be occasioned by the animals pasturing on damp ground; and it is stated that, in close muggy weather, a whole flock has been plague-stricken in less than a quarter of an hour. In former

times, a very serious loss was not unfrequently incurred by the occupiers of sheep-farms, from extensive ravages of this fatal disorder; but such accidents, in our days, have happily become rare, from greater attention being paid to draining, and other improved methods of management, in every department of husbandry.

As serious losses sometimes happen to farmers, from carelessness as to the mode in which their flocks or herds are penned and housed, I would here call their attention, especially, to this branch of their business.

Knowing that all living animals, for the healthy performance of their functions, require abundance of atmospheric air; without this necessary ingredient be sufficiently supplied them, they will speedily become sickly and ill-favoured. Indeed both men and brutes, when crowded together, in badly-ventilated apartments, exude a peculiarly noxious effluvium, which, in the human being, oc-

casions fatal diseases; in the horse, the glanders; in dogs, the distemper; and in fowls, the pip.

In respect to the employment of green herbage, in raising crops of grain, pulse, or tuberous-rooted vegetables, and of the propriety of growing certain descriptions of plants to be available for this purpose, with the prospect of obtaining a profitable remuneration, much difference of opinion among agriculturists, I am aware, exists; and the locality of the estate, and the peculiar quality of the land, have probably much to do with the question at issue.

Such species of herbage can only be advantageous, so far as, by its deeper rooting, it is enabled to extract, from the sub-soil, those properties which the crop, it is designed to manure, has not the capacity to reach; and the adaptation of this system to his customary mode of culture, must be decided by the circumstances and judgment of the agriculturist.

If, however, an individual living at a great

distance from towns and places where manures are readily to be procured, should be desirous of trying such mode of cultivation, or of extending it farther than he has hitherto attempted, from being but imperfectly acquainted with the kind of herbage generally grown for such purpose ; he will find the names of plants suitable, in a treatise lately translated into English, together with the constituents of which they are formed, as recently determined by a scientific German chemist ;* and from this work he can select those which may seem likely to suit his views ; always bearing in remembrance, that the soil on which they are employed should be light and sandy ; and when the herbage is ploughed in, the plant should be in flower.

* Sprengel.

CHEMISTRY MADE EASY.

"The very law that moulds a tear,
And bids it trickle from its source,
That law preserves the earth a sphere,
And guides the planets in their course."

HAVING, in the foregoing pages, endeavoured to show the advantages which practice, in union with science, will necessarily produce, in whatsoever art or business their powers shall be jointly engaged; and presuming that most of my readers are well versed in the former, as far as relates to the mere operative part of their vocation, and but few acquainted with the latter, so as to be able to trace the modes of action of the agents they usually employ; I shall now attempt, as plainly as the subject will admit, to set before them so much information, in Chemis-

try, as may be necessary for the clear comprehension of the terms (viz.: the things they represent) which it uses; to show the manner in which chemical action is performed; the multifarious objects over which its influence extends; and the method by which it explains the qualities, and exposes the constituents of the respective objects on which a farmer's attention and capital are usually exercised.

Chemistry is the science which enables us to investigate the mutual action of bodies upon each other; to unravel the web of nature, and thus discover the elements of which the things that are around us are constituted. It performs its operations by a play of combinations and decompositions; of likes and dislikes; through which it unites dissimilar substances, into new compounds, totally unlike in appearance and qualities, to the ingredients of which they were composed. This it does, not in masses, or at random; but in definite proportions, and by

indivisible quantities, situated at an inconceivably small distance from each other.

It informs us of particular bodies which the skill of man has, as yet, been unable to decompose, styled elements; of gases, acids, salts, alkalies, earths, and oxides, by the combination of which, under certain modified forms and qualities, the whole material part of the universe is constructed, renovated, and kept in being. Such of these as shall have connection with the purpose in view, I shall now bring, briefly, under your notice and consideration; premising the subject with the observation, that in all chemical action, *heat* is disengaged; as is most powerfully manifested to the senses, during the decomposition of a heap of stable manure; and is present in every material, either in hidden, or perceptible form. It is the cause of fluidity, and known to men of science by the name of caloric; and when abstracted from water, the latter becomes a solid mass, (ice.)

Two modes are used in investigating the nature of objects, desired to be ascertained, viz.: by effecting the union of two or more substances, into one compound, called synthesis; and by disuniting the ingredient, of which a substance is constituted, and exhibiting them in a separate state, termed analysis.

There are two descriptions of analysis, the qualitative and quantitative. An examination of the first kind is performed, simply, by means of re-agents or tests, which, by producing a known change or appearance in the solution into which they are poured, indicate the nature and number of the particular substances it holds dissolved; whilst, as considerable skill in manipulation is required for the management of the second, and accuracy in weighing, to ascertain the quantities of the results thrown down or *precipitated*, it can seldom be effected properly, except by an experienced chemist.

Elementary bodies are the metals, oxygen,

hydrogen, nitrogen, carbon, silicon, sulphur, phosphorus, chlorine, &c.

The metals, of which there are in number forty-two, are obtained in different stages of purity, from the various strata of the earth, or in combination with acids and other substances. When extracted from their ores, they possess, in general, lustre, opacity, and fusibility; and many of them malleability, and the capability of being drawn into wire.

Oxygen exists pure only as a gas; which is a substance, in a permanently aeriform condition, and is that constituent of atmospheric air, by which the respiration of men and animals is supported. It enters largely into union with metals, &c.; and is the principal cause of sourness, rustiness, and rottenness.

Hydrogen is also a gaseous body, and, in combination with oxygen, forms water. It is one of the most universally diffused elements in creation,

is eminently combustible, and the lightest of all known substances.

Nitrogen is of a similar nature to the two foregoing, existing separately only as an elastic invisible gas, and enters largely, as a diluent, into the composition of the atmospheric air. It is characterized by its inaptitude to combine with other elements. It exists in vegetables, and constitutes a principal portion of the flesh of animals. It abounds in ripe grasses, especially in their seeds; also in peas, beans, and vetches.

Carbon is the basis of coal, oils, and fat, and constitutes nearly the whole of the solid parts of trees and vegetables.

Silicon is derived from flint and sand.

Sulphur is a yellow inflammable substance, obtained generally from the neighbourhood of volcanoes.

Phosphorus is an inflammable substance, de-

rived from bones, urine, &c., and is to be found in most vegetables, especially in wheat, oats, &c

Chlorine exists as a green-coloured gas.

Acids are substances which, when applied to the tongue, usually produce the sensation termed sourness, and most commonly contain oxygen. The compounds they form, in union with other bodies, are known by the name of salts.

The acid which more especially concerns the agriculturist is carbonic acid, which exists naturally in a gaseous form, and is constituted of two parts of oxygen and one of carbon. It is produced during the respiration of men and animals, and in the common process of burning wood and coals. From these sources it is present, in a small quantity, in the atmosphere, and acts a most important part in the support of plants, which convert its carbon into their substance, and give back its oxygen to the air.

In the early eras of the world's history, it is supposed that the atmosphere was loaded with a

much greater amount of carbonic acid gas, than is discoverable therein at the present period; so that the trees of the primeval forests hugely devoured carbon for the formation of their respective structures, and exuding a portion at their roots, produced vegetable mould; which forests, when laid prostrate by tempests, or decayed by age, in combination with the gigantic ferns which constituted their underwood, became transformed into those carboniferous rocks or coal strata, whence the inhabitants of all civilized countries are, at this day, furnished with fuel; and to which this kingdom is, in a very considerable degree, indebted for its commerce, its wealth, its independence, and its greatness.

The formation of an acid may be familiarly shown, by moistening the interior of a tumbler glass with a small portion of water, by means of a sponge; and, having inverted it, burning under it a sulphur match; when the sulphur, combining with the oxygen of the air, will impart a sour

taste to the liquid, adhering to the sides of the glass, viz.: sulphuric acid.

An alkali is a caustic acrid body, possessing the property of converting the blue juices of many vegetables into green; and the term is more especially used, to designate the well-known substances, potass, soda, and ammonia. The first of which is derived, abundantly, from the ashes of plants: the second from common salt; and the third is formed during the decomposition of animal and vegetable matter; and consists of one atom of nitrogen, and three atoms of hydrogen.

The compounds which alkalies form with acids are also called salts; the same appellation being given to unions of acids, with the two classes of bodies, of which we shall speedily treat; namely, earths and oxides.

Earths are certain insoluble substances, having each a metallic base, viz., lime, alumina, silica, magnesia, baryta, and strontia; the first four of

which are of abundant occurrence in soils and rocks; lime being the principal constituent in limestone, chalk, gypsum, and marl; alumina in clay; silica in sand; and magnesia in a variety of minerals. Some of these earths also exercise a similar action with alkalies on vegetable colours, and are therefore styled alkaline earths.

Oxides are, generally speaking, unions of metals and other bodies with oxygen; and among them, from their having metallic bases, are comprehended the earths, and the alkalies, potass and soda.

The formation of a salt will be shown in the following experiment.

If a few grains of magnesia be gradually dropped into a wine glass containing sulphuric acid, diluted with water, as long as bubbles shall be observed to arise to the surface, and then discontinued, the liquid will be discovered to have lost its sourness, and the taste of the magnesia will also have disappeared; whence the com-

pound is called a neutral salt; and it is, as such, that most salts are found existing in soils. By evaporating a portion of the solution, and suffering it to remain undisturbed, crystals will speedily be formed, known as sulphate of magnesia; the name of each salt indicating the acid and base of which it is constituted.

Salts, therefore, are compounds of an acid with an earth, alkali, or metallic oxide; and in crystallizing, each assumes its own determinate and peculiar shape. Thus nitrate of potass (nitre) forms prismatic octahedrons; sulphate of soda, (glauber's salt,) six-sided prisms; chloride of sodium, (common salt,) cubes.

The following important chemical compounds, albumen, fibrine, gluten, casein, farina, (or starch,) sugar, and gum, are products formed during the growth of plants. The four first are identical in their elements with blood and muscle, and may therefore be termed the flesh-forming substances. The three latter each consist of

the same principles, and are necessary for the constitution of oils and fat; and when taken into the circulation, tend to the support of respiration in animal life.

Albumen and fibrine, together with starch, constitute the flour of wheat. The two former hold nitrogen in their formation; the latter is without it. Casein abounds in beans and peas, and is a constituent of milk.

Vegetable gluten, as obtained from wheat flour, consists of vegetable fibrine, with a small quantity of a foreign substance, which gives to it its adhesive glutinous property. By different writers, however, fibrine and gluten are frequently used to signify the same substance.

ILLUSTRATIONS.

If into a glassful of ale, which has become tart, a few grains of carbonate of soda are thrown, the liquor will be rendered mild and brisk. The acid which occasioned the sour taste, (acetic.)

having a stronger affinity for soda than carbonic acid has, herein combines with the soda, and liberates the other, in the form of carbonic acid gas; and it is to the presence of this gas that cider, perry, and sparkling wines, owe their effervescing qualities.

In washing the hands in ordinary spring water, known as *hard*, the soap used in the operation will frequently have been found to have been almost useless, and the liquid to have assumed a curdled appearance. This is occasioned from the decomposition of the soap, which is formed of an alkali and tallow, by the acid of the carbonate of lime, (which caused the hardness,) uniting with the alkali of the soap, and releasing the tallow, which showed itself, as before stated, upon the surface of the water.

If into a dry tumbler-glass, a few grains of oxalate of potass are placed, and water, from a similar source, poured upon it, the water will become turbid, owing to the combination of the

acid with the lime, forming an insoluble compound, (oxalate of lime.)

The presence of common salt may be detected by a few drops of nitrate of silver in solution; and that of iron by a small quantity of an infusion of nutgalls. The oxalate of potass, nitrate of silver, and nutgalls, thus applied, are termed tests.

Certain springs, (as at Matlock and Knaresborough,) called petrefying waters, contain carbonate of lime, in solution, in large quantities, which is partially decomposed and deposited, on coming in contact with the atmosphere, so that substances placed therein, in a few weeks become coated with that material.

A cause of softness in rain-water is due, first, to its not containing such salts, and consequently not curdling soap; and also to its holding in solution a small portion of the carbonate of ammonia. It is these earthly salts, in solution, which cause what is termed "furr," in tea-kettles

and other culinary utensils; the acid with which they are combined being driven off, by the heat of the fire, the lime is deposited on the sides and bottoms of the vessels.

In cutting an apple with a polished steel knife, the part of the blade which has come into contact with the fruit, will have been observed to have become black, as if stained with ink. This stain is occasioned by the acid of the apple, (malic,) combining with the iron, and freeing from it the carbon with which it was united, in the formation of the material,—steel.

On a portion of a recently-hung gate, constructed of oak timber, we may frequently have observed a dark blue-coloured stain, which was caused by a union of the gallic acid of the oak with particles of iron, abraded from the sides of the saw, whilst cutting the wood, and is, in fact, genuine ink; this fluid being a compound of these two substances, with the addition of a small quantity of gum arabic, to give it a body,

that it may be retained by the pen, when used in writing.

What are termed chalybeate springs, are so named from holding iron in solution; and it is no less true than curious, that the brown sediment which may frequently be observed in pools and shallow water-courses, is occasioned by the cast-off skins of minute animalculæ, (infusoria,) the principal constituent of which is iron. These creatures are invisible to the naked eye, but are ascertained, by the microscope, to exist by hundreds in every drop of pool or river water.

Indeed such exuviæ are, in some districts, accumulated in masses, as to form immense beds of ore; and this invaluable metal is extracted for the use and convenience of mankind, as it were, from the sloughings and offscourings of insects. Thus we perceive how, from apparently insignificant means, the most gigantic results are planned and perfected by an all-wise and beneficent Creator; and whilst we behold, we should adore.

Should a ploughshare, or any other iron instrument, be suffered to remain a few nights exposed to the action of the moist atmosphere, it will acquire a coating of a brown colour, termed rust. This is caused by the oxygen of the air uniting with the iron, and forming an oxide. It is owing to iron, in this condition of oxidation, that a brown or yellow colour is communicated to clay, sand, &c.

Dissolve any given quantity of marl, in diluted muriatic acid, pour off the fluid from the undissolved matter, and to it add a small portion of common potass, dissolved in water; lime, which makes it valuable, will be thrown down or *precipitated*, and the proportion present can be thus ascertained. The muriatic acid having a greater affinity for potass than for lime, deserts the latter, and combines with the former.

In stables, wherein a powerful smell of hartshorn (ammonia) is perceptible; if an ounce of muriatic acid, (on a plate,) be placed therein.

dense white fumes will be seen in its neighbourhood, which are devoid of all smell. This is muriate of ammonia. The acid having a strong affinity for this alkali, has attracted and retained it. And I here venture to suggest, that if, in stables, the floors were occasionally sprinkled with water, containing muriatic acid, in the proportion of two ounces of the latter to a gallon of the former, the smell would be considerably destroyed, and the injurious influence of the ammonia, upon the horses, be greatly weakened.

If an ounce of oil of vitriol be poured into three separate wine-glasses, and in the first there is inserted a piece of straw; in the second is placed a small portion of cork; and into the third, is dropped a lump of loaf-sugar, the three substances will become black; the straw appearing as if it had been charred by a fire.

The oil of vitriol (sulph. acid) has, in these three instances, united with the constituents of these several substances, except their carbon,

which imparts the well-known black colour of charcoal to the parts remaining. In the instance of the sugar, which is composed of carbon and of water, it has merely abstracted the elements of the water, (hydrogen and oxygen,) and left the carbon untouched.

If a small quantity of oak saw-dust, well pressed into the bowl of a large tobacco-pipe, (the mouth of which is closely coated over with pipe-clay,) be submitted to the action of a clear fire, a species of vinegar, (pyroligneous acid,) will be distilled from the end of the tube, and charcoal be found remaining after the operation is concluded ; which charcoal, when burnt in the open air, will leave a small residue of white ashes, containing potass and a very minute quantity of insoluble matter, consisting principally of lime.

These latter mineral substances, not being destructible by fire, are styled *inorganic* constituent of plants, whilst those which are resolvable into elementary bodies, and fly off to form new com-

binations, (as carbonic acid, &c.,) are termed *organic* substances. Thus by ascertaining what are the elementary principles of which vegetable substances are constituted, we are enabled to form a tolerably correct opinion of the species of manure, that will best promote their health and vigorous growth.

The production of water may be observed, during the burning of a gas-lamp, in a coffee-room, &c.; where a funnel-shaped chimney is frequently to be seen suspended over the flame, attached to a tube, having a glass globe at its extremity, generally containing a fluid generated during the combustion of the hydrogen gas, in union with the oxygen of the atmospheric air,—which is water.

The chief constituents of corn,—fibrine and starch, may be obtained in the following manner. Enclose a portion of the flour of wheat, made into a paste with *cold* water, in a small muslin bag, which squeeze in a gentle manner, in a basin

of cold water, so long as any white particles are discharged from the bag. The residue in the bag is fibrine, and the powder in the basin is starch.

By rubbing an unripe apple upon a grater, and washing the portion which is rasped off, in cold water, starch will also be collected; which starch, had the apple been suffered to remain until ripe, would have been converted into sugar, forming the sweet juice of the fruit.

Potatoes also contain from 10 to 12 per cent. of starch, which may be separated by the foregoing process. Arrow-root is starch obtained from a species of reed; sago, from the pith of the palm; and tapioca from a plant which both yields this bland food, and a virulent poison.

CHEMISTRY MADE EASY.

"See dying vegetables life sustain;
See life dissolving, vegetate again:
All forms that perish, other forms supply;
(By turns, we catch the vital breath, and die;)
Like bubbles, on the sea of matter borne,
They rise, they break, and to that sea return."

Your attention is now called to the process by which plants live and are nourished; and in order to comprehend the subject properly, it is necessary that you should become well acquainted with the nature of the substances with which they are constantly in contact, viz.: the air, earth, and water.

The air or atmosphere is composed of two gases, oxygen and nitrogen, *mixed* together in the proportion of 21 per cent. of the former, and

79 of the latter. Besides these elements, there are always present, watery vapour and carbonic acid gas; the latter being an important constituent in vegetables, and forms about one-thousandth part of the whole mass of atmospheric air.

Water consists of two gases, chemically combined, in the proportion of 12 per cent. of hydrogen, and 88 of oxygen, and possesses the power of dissolving a vast number of substances; and which, when it descends upon the earth as rain, contains, in solution, carbonic acid, derived from the atmosphere, and carbonate of ammonia, from the putrefaction of vegetable and animal matter. These, together with the soluble substances it meets with in the soil, it brings into contact with the roots of plants.

In treating of this portion of our subject, we must not omit saying a few words respecting certain agents, some of which, until of late years, had been but imperfectly investigated, as respects their influence over the process of vegetable life.

In the operations of nature, the light of the sun, in combination with the electric fluid, is probably the grand decomposing and combining instrument. This latter subtle and mysterious power pervades all material things, and is supposed to be the proximate cause of attraction, in the particles of which visible objects are compounded. "The functions of vegetables," says a learned writer, "are either excited or regulated, in a great degree, by the stimulus of light, heat, electricity, and oxygen, which are essential to healthy transpiration, to absorption, to the decomposition of carbonic acid, the fixation of carbon, the production of colour, and to the elaboration of nutritive fluids and distinct secretions;" and being thus necessary to the perfection of vegetable existence, should, as little as possible, be obstructed by objects, which may not absolutely be wanted in the economy of a farm. So powerful an agent is light, that it even affects the nature and nutritive qualities of plants

and on some, so astonishing is its influence, (as on the cotyledon calycinum,) that their leaves will be sour in the morning, insipid at noon, and bitter towards night:

> "The bud may have a bitter taste,
> But sweet will be the flower."

It has been already stated, that plants imbibe their nutriment, in a state of solution. It now remains to be explained, by what parts of the vegetable this nutriment is taken into the circulation, and of what such aliment consists.

The nutriment of plants dissolved in water, is absorbed by the young extremities of the roots, a portion also being imbibed by the leaves from the atmosphere.

The fluid containing the food of the plant, ascends into the stem, and is familiarly known as the sap; and from it, all the various organs, secretions, and excretions, are formed, in the cells of which the vegetable structure is composed.

Of what their nutriment consists, may be

ascertained by considering the following simple experiment.

Seeds sown in powdered marble, (an insoluble substance,) after being watered and exposed to the atmosphere, have sprung up, flourished for a time, and then died.

It has been shown, that rain-water holds in solution carbonic acid and ammonia, so that the plants, arising from such seeds, had vegetated, sprung up, and derived the solid materials which formed their consistence, from the following three substances, viz.: water, carbonic acid, and ammonia. After a time, however, they withered and died, showing that some other materials were necessary for their future nutrition, which were not present in the powdered marble, but which are generally to be found in ordinary soils.

These requisites have been discovered to be various mineral substances, chiefly of an alkaline character, the most prevalent of which is potass.

We thus reduce the nutriment of plants to

nitrogen, which exists in ammonia; to water, which is composed of hydrogen and oxygen: and to carbonic acid, consisting of carbon and oxygen; together with certain mineral products, of which different kinds are required by different species of plants. Further proof of the necessity of the presence of the first three substances, is afforded by the fact, that the wood of which the greater part of a tree is constituted, is composed of carbon, combined with hydrogen and oxygen, in the proportions to form water, whilst the nitrogen is found, principally, in the roots and seeds.

We have thus obtained a knowledge of the nature of the food or nutriment, required for the support of the vegetable kingdom generally; let us now see whether, by some simple experiment, we can procure further insight into this most important subject.

We have seen that the vegetable, planted in the pulverized marble, died for the want of

certain mineral substances, not afforded by the materials mentioned in the experiment.

Suppose we take equal weights of various vegetable substances, and burn them; we shall find that we shall obtain a larger amount of ashes from some species of plants, than from others; and the quantity of ashes thus yielded, will indicate the proportion of alkalies in the plant burnt; so that we clearly prove, that some vegetables require more alkalies than others, for the healthy development of their organization.

The salt, known in commerce as pearl-ash, is obtained by burning plants, and dissolving this article from their ashes; and it is found that the branches yield more of this substance than the trunk of the same tree, which circumstance is accounted for, by the potass existing chiefly in the sap with which the young parts of the tree are filled.

If we burn any of the grasses, and especially their seeds, we shall find in their ashes another

salt, called phosphate of magnesia, which exists in the plant, in combination with ammonia. This we shall afterwards find to be an important fact, as corn is one of the grass-tribe, as is also the herbage upon which cattle are usually fed; and consequently, wherever this vegetable is grown, phosphate of ammonia and magnesia must be present in the soil.

There is also a salt in these plants, so necessary to the supply of food, for the population of this and the several countries of Europe, which forms a coating to the stalk, thus acting as an external skeleton, for the support of the grain.

We see this coating exemplified on a large scale, in the varnish-like covering of the sugar-cane, bamboo, &c., and also in the shining exterior of the straw of wheat. This coating is a perfect glass, manufactured by the plant, from the constituents of the soil in which it was grown; and if we take a single straw of hay, and carefully and gradually burn it, in a clear but strong flame,

we shall find a globule of glass at the unconsumed extremity of such stalk.

Now as this coating is there existing, for the purpose of affording support to the straw and grain, and is derived by the plant from the soil in which it grows, it is evident that the substances necessary for its formation must be present in that soil. These substances are silica, (or sand,) and potass. If these therefore do not exist in the soil, in some form or other, in vain will the agriculturist attempt to obtain crops of corn; and he must either cultivate such land with some other species of vegetation, which does not require these materials, or he must add them to his field by means of manures, either artificial or otherwise.

Let us now re-consider some of the foregoing statements, and the conclusions which may be deduced from them.

We have seen, that a plant derives the salts which it contains, from the soil in which it grows;

that different species of plants require different salts for their nourishment; and that, as some soils contain one salt and other soils another, so, of necessity, one soil will be more fitted for the growth of certain plants than for that of others; and as all subjects are more easily understood, when examples of the fact can be brought under notice, let us endeavour to find one, bearing upon that we are now attempting to elucidate.

One of the principal constituents of soil is decayed wood, which by chemists is called Humus. By the action of the oxygen of the atmosphere, this substance, which consists mostly of carbon, is converted into carbonic acid, which, being dissolved by the rain, affords abundant carbonaceous nutriment to the plants.

Humus abounds in peaty soils, and its effects are manifest in the corn cultivated in such localities, (as on fens or reclaimed marshes,) which, for a time, flourishes luxuriantly, but afterwards bends under the influence of the first heavy

shower of rain, and is never able to regain its erect position, because there is not the material present in the soil, from which it can manufacture its cylinder of flint-glass, to support its straw and ear, and consequently, such soils have had sand added to them, with great advantage to the crop of wheat grown thereupon.

Experience has taught the agriculturist, that it is impossible to cultivate the same species of plant for many successive years, upon the same soil, without the addition of manure, or even with the addition of certain kinds of this material. It has also shown him, that some manures are more suited for one kind of soil than another.

From the considerations in which we have been engaged, these circumstances become of easy explanation.

The reason why it is not possible to grow the same kind of plant upon the same land, for many successive years, is, that the plant extracts from the soil, and converts to its own substance, all

those soluble portions therein, which it requires; returning by the roots, or leaving such portions which, although not useful to it, may be so to others. Thus the land which grows one species of crop in one year, is able to produce a crop of another kind, in the succeeding year, even without the aid of a manure. If, however, proper manure is supplied to the soil, the same plant may be cultivated on the same land, for very many successive seasons. These considerations explain the theory of the alternation of crops.

A knowledge of the chemical constituents of certain plants, and of the chemical constitution of the soil on which they are purposed to be cultivated, will therefore enable the farmer to ascertain what plants are best suited for the profitable management of the succession-crop system.

Whilst upon this subject, it may not be out of place to say a few words, on the use of permitting land to lie fallow, which is to allow the sun and air to have free access to it, which, operating

upon such constituents of the soil as shall not have been appropriated by previous crops, draw forth a fresh supply of food, fitted for the support and growth of the same description of plant as had recently been grown upon it.

By allowing a field to lie fallow, it will be remembered, that the farmer derives no profit from the land, during the year it is so unemployed; whereas, by cultivating it with another sort of seed, he secures the advantage of the fallow system, and at the same time obtains a crop of a different kind of plant, he being careful however to cultivate such a species of plant as, during the progress of vegetation, shall not require nutriment, wanted by the grain which he purposes to succeed it; and if instead of employing the crop which shall be grown upon the field, that, in the usual course of husbandry, would otherwise have been in fallow, for immediate pecuniary profit, it shall be ploughed into the soil, when it has nearly arrived at maturity,

the land will thus again receive all that the plant had abstracted, together with the carbon, which it derived from the atmosphere, and appropriated to the formation of its substance.

Manures are materials, by means of which we add to the soil, on which we desire to grow certain plants, such known constituents of these plants, as the soil is found by chemical analysis to be deficient in.

To take the instance of corn. This grain, we have seen, requires the presence of silica, potass, and phosphates, for its healthy growth. If the land upon which it is cultivated does not contain these substances, the farmer must endeavour, by manure, to give the soil the materials of which it is in want, or his capital and labour will be expended in vain.

In order to do this with advantage, he must study to obtain a knowledge of the constituents of the various manures in general use.

In the horse-dung of the stable manure, the

silicate of potass and phosphate of magnesia exist; and in the straw which has served as litter, a supply of silicates and phosphates will also be found; whilst the urine, with which the litter is saturated, affords ammonia; and by the application of these ingredients to our fields, we supply to the corn-land the materials which have been exhausted by the last crop. And it must be carefully borne in mind, that the use of manure containing nitrogen, (one of the constituents of ammonia,) is indispensable to the successful cultivation of every species of corn.

Since the resources of chemistry have been applied to the purposes of agriculture, attention has been directed to various manures, besides those produced in our stables and fold-yards, which are calculated to exercise a beneficial influence upon the respective plants cultivated on a farm. Many of these compounds, when tried, not happening to realize the expectations formed by the persons who applied them, have been

stigmatized as valueless. But this judgment has, perhaps, been pronounced too hastily. For it is evident from what we have been considering, that we must first obtain a correct knowledge of the composition of the land, before we can, on rational principles, attempt to supply what is deficient, for the support of the plants designed to be cultivated upon it. And not only so, but we must preserve and apply all descriptions of manures, in such a form as will best secure and retain the active properties they may possess.

Many individuals, I fear, in this particular, are culpably negligent, permitting the litter from their stables and cow-sheds to lie for months exposed to the influence of the weather, and thus lose one of its most active agents—ammonia; whilst the soluble salts are dissolved out by the rain, and drain away. Whereas, such manure, if not wanted at the moment, should always be well pressed together, (by drawing the carts over it,) and be covered with a thick coating

of soil, in order to prevent the escape of the substances which especially constitute its worth.

The practice also of burning scutch, weeds, &c., is greatly to be reprehended. For if such materials were carefully collected into large heaps, and interspersed with layers of quick-lime, they would soon be reduced to a state capable of yielding again, to the land, the constituents of which it had been robbed. Whereas, when consumed, the carbon is dissipated, by uniting with the oxygen of the atmosphere as carbonic acid, and nothing remains but the earthy and alkaline salts, which are comparatively insignificant in quantity, and consequently of trifling importance to the soil.

Lime indeed, when employed upon land, should always be applied fresh from the kiln, as it quickly loses a portion of its virtue, on exposure to the air, by imbibing water and carbonic acid. Whereas, whilst caustic, it aids in pulverizing the clods, destroys sourness, decomposes vegeta-

ble-matter, aluminous earths, combinations of iron with acids, salts, and bone-dust; but should it contain much magnesia in its composition, (which may in a degree be discovered, by its brown appearance and soapy feel,) it should then be altogether discarded, as this mineral, when over-abundant in soils, is most noxious to almost every description of plant.

The highly-fertilizing qualities which putrefied urine possesses, have been already noticed. So important a material is this and human excrements, that Liebig asserts, that "every town and farm might thus supply itself with the manure, which besides containing the most nitrogen, contains, also, the most phosphates; and if rotation-crops were adopted, they would be most abundant." So beneficially has this description of manure been applied to land, in the vicinity of Edinburgh, by irrigating the fields from the "FOUL BURN," into which the contents of the privies, the sinks, and drains of the town, are

received; that three hundred acres of meadow land, contiguous to the palace of Holyrood House, are let at from £10 to 20 per acre, and some as high as £30! With this fact on record, will the plan suggested in the former part of this treatise be by farmers disregarded?

Guano, which is the excrement of certain sea-fowl, like urine, abounds in ammonia, and in phosphates; and also in sulphates of soda and potass.

Besides manures, afforded by nature, for the supply of our fields, with the materials which have been abstracted from them by cultivation, human ingenuity has devised certain artificial substances, which may perform the part of a manure; and in soils which are deficient in alkalies, these artificial manures are highly useful in supplying them; and it is in this way that crushed bones, which are constituted of phosphate of lime and magnesia, sulphate of potass, ammonia, muriate and carbonate of soda, act.

Not only are such salts extremely valuable, in aiding the growth of plants, when applied alone to the soil, but experience has shown, that their virtues are increased by admixture with others. Thus a solution of equal parts of common salt, nitrate of soda, and subcarbonate of potass, worked into a heap of well-rotted stable manure, just previous to spreading, is reported to have most materially increased the yield of wheat; and equal quantities of crushed bones and guano,* have proved highly beneficial, when applied to grass land, potato and turnip crops. It has also been asserted, that wheat, oats, barley, and other seeds, steeped in solutions of sulphate or carbonate of ammonia, nitrate of soda or potass, for the space of twenty-four or thirty hours before sowing, have caused a much more abun-

* These substances must be applied with judgment and discretion; as bone-manure, where it has been copiously used in Cheshire, is said to have altered the taste, and deteriorated the quality of the cheese, for which that county has for ages been celebrated.

dant produce, than would have been the case had the seed been submitted to the land, in its natural state, after the customary practice. The experiment is therefore worthy the consideration and trial of all intelligent agriculturists, as the expense of making such solutions is very trifling.

Before we conclude this little treatise, it may not be irrelative to the subject to introduce a short passage, on the process of digestion, or concoction and conversion of vegetables into food, suitable for replacing the animal waste of the body, which is conducted and effected in the following manner.

Grasses and other substances being taken into the mouth, are there crushed and commingled with saliva, (which contains oxygen,) and then passed into the stomach, where, by means of a slimy fluid, (mucus,) and a sourish secretion, (gastric juice,) they become reduced to a state of pulp, and thus capable of being taken up by

organs formed for ministering to the renewal of the structure of such parts of the corporeal frame, as are constantly subject to flux and change. In man, and all carnivorous animals, the process is extremely simple. For muscle and blood being formed of the same chemical constituents, the stomach speedily reduces these to a uniform mass; which, being passed into the system, traverses the lungs in the form of blood, where it loses a portion of its carbon, absorbs oxygen, and supports and increases the size of the body, by depositing flesh in one part, and fat in another.

In rainy seasons, grass is generally washy, and less nutritious to cattle, than when the weather is dry; it is consequently advisable to supply them, at those periods, with food possessing such properties as will compensate for the defective provender, which the fields then afford them; and, (as all kinds of pulse abound in albumen and casein,) if half-a-peck of bean-flower, mixed in a

peck of cut-chaff, were administered to cows, each morning and evening, considerable advantage would be derived from such feed, both as respects the condition of the animals, and the quantity and quality of their milk; but this food being defective in phosphates, which are necessary for the formation of bone, will not be so proper for young and growing cattle.

Thus, then, have we seen how by a beautiful process of selections, transformations and combinations, vegetables form their structure, juices, seeds, and fruit; whereas, men and animals merely appropriate to the support and growth of their bodies, substances already prepared for them by the hand of nature; and in the pursuit in which we have been engaged, the writer of this little treatise trusts he has not altogether failed in showing in what manner a knowledge of chemistry is useful to the business of agriculture; in explaining its terms, so as to be comprehended by persons unacquainted with the

language of science; and in giving such an insight into its general modes of action, as may induce many of his readers to make further inquiry into a subject, which is not important to their individual interests alone, but to the wealth and prosperity of the nation, of which they are a part; being, (in the opinion of him,* who at the same time that he was the most powerful genius that ever employed his energies in the boundless arena of chemical research, in this country, was the first to elucidate the bearing of chemical science, as applied to the purposes of agriculture,) "one of those pursuits, which, whilst in their sublime speculations they reach to the heavens, in their application they belong to the earth; whilst they exalt the intellect, they provide food for our common wants, and likewise minister to the noblest appetites and most exalted views belonging to our nature. They keep alive that inextinguishable thirst after knowledge, which is one

* Sir H. Davy.

of the greatest characteristics of our nature; for every discovery opens a new field for investigation of facts,—shows us the imperfection of our theories.

"It has been justly said, that the greater the circle of light, the greater the boundary of darkness by which it is surrounded. This strictly applies to chemical inquiries; and hence they are wonderfully suited to the progressive nature of the human intellect, which, by its increasing efforts to a higher kind of wisdom, and a state in which truth is fully and brightly revealed, seems, as it were, to demonstrate its birthright to immortality."

APPENDIX.

Analysis of Albumen, Gluten, Casein, and Flesh.

	ALBUMEN.	CASEIN.	GLUTEN.	FLESH.
Carbon ···	35·0	54·0	54·2	54·12
Hydrogen	7·0	7·0	7·5	7·89
Nitrogen··	15·9	15·6	14·0	15·72
Oxygen···	22·1	23·2	24·4	22·03

Analysis of Sugar, Starch, and Gum.

	SUGAR.	STARCH.	GUM.
Carbon ·····	12	12	12
Hydrogen ····	11	10	11
Oxygen·····	11	10	11

The above pass into a substance, precisely similar to animal fat, by abstracting a portion of their oxygen; it therefore may be seen, how food abounding in these compounds tends to promote the deposit of that substance in cattle.

Analysis of the Milk of a Cow.—*Playfair*

Casein·····	4·0
Butter·····	4·6
Sugar ·····	3·8
Ashes ·····	0·6
Water·····	89·0

Analysis of Human Urine, 1000 parts of which contain as follows :— *Berzelius.*

Urea	30·10
Free lactic acid, lactate of ammonia, and animal matter	17·14
Uric acid	1·00
Mucus	0·32
Sulphate of potass	3·71
Sulphate of soda	3·16
Phosphate of soda	2·94
Phosphate of ammonia	1·65
Chloride of sodium	4·45
Muriate of ammonia	1·50
Phosphates of magnesia and lime	1·00
Silicious earth	0·03
Water	933·00
	1000·00

The urine of horses contains less nitrogen and phosphates than that of man; that of cows is abundant in salts of potass; and that of swine, rich in phosphate of magnesia and ammonia.

Putrid urine, to which gypsum has been added, forms an excellent manure for cabbage, celery, turnips, red clover, and all culinary vegetables.

Analysis of Peas, Lentils, and Beans.—*Playfair.*

	PEAS.	LENTILS.	BEANS.
Carbon	35.743	37·38	38·24
Hydrogen	5·401	5·51	5·84
Nitrogen } Oxygen }	39·366	37·98	38·10
Ashes	3·490	3·20	3·71
Water	16·000	15·90	14·11
	100·000	100·00	100·00

Analysis of Red Clover.—*Sprengel.*

1000 lbs. of red clover contain, when dried,—

Nitrogen	17 lbs.
Potass	28 —
Soda	5 —
Lime	28 —
Magnesia	37 —
Sulphuric acid	47 —
Phosphoric acid	67 —
Chlorine	37 —
Carbon	550 —

Silica, iron, alumina, manganese, oxygen, and hydrogen, make up the remainder.

Analysis of Hay.

100 parts of hay, dried in the air, contain—

Dry matter	86
Water	14
	100

100 parts of hay, dried at 212° equal 116·2 parts dried in the air, and contain—

Carbon	45·8
Hydrogen	5·0
Oxygen	38·7
Nitrogen	1·5
Ashes	9·0
	100·0

Analysis of Bones.

Bones consist of 42 parts of lime and 36 of phosphoric acid, together with animal-matter, termed gelatine, which is also a valuable manure, although frequently abstracted before the farmer obtains them. Digested in diluted sulphuric acid, their virtues have been highly extolled in the cultivation of turnips.

Analysis of Guano.—*Völckel.*

Urate of ammonia	9·0
Oxalate of ammonia	10·6
Oxalate of lime	7·0
Phosphate of ammonia	6·0
Phosphate of magnesia and ammonia	2·6
Sulphate of potass	5·5
Sulphate of soda	3·8
Sal-ammoniac	4·2
Phosphate of lime	14·3
Clay and sand	4·7
Organic substances not estimated, containing 12 per cent. of matter insoluble in water, soluble salts of iron, in small quantity, and water	32·3
	100·0

Analysis of Gypsum.

Sulphate of lime, known in several parts of England under the name of talc and gypsum, is constituted of 46 parts of sulphuric acid, and 28 of lime, and when spread, in a powdered condition, on the surface of the soil, has been found to be highly beneficial to crops of grass, mustard, and clover. Herbage, rich in sulphates, is said also to be necessary to the production of the fine wool in sheep.

Analysis of Oats.—*Boussingault.*

100 parts of oats, dried at 212° equal 117·7 parts dried at the ordinary temperature, and contain—

Carbon	50·7
Hydrogen	6·4
Oxygen	36·7
Nitrogen	2·2
Ashes	4·0
	100·0

Oats dried in the air, 117·7, contain, in 100 parts, 1·867 of nitrogen.

Analysis of Potato Roots.

Water	76·6
Starch	11·2
Lignin	7·8
Mucus and salts	3·7
Albumen	7
	100·0

The stalks of ripe potatoes contain lime, magnesia, and potass, and abound in nitrogen, and are consequently a valuable manure, as is also the straw of vetches, for the same reason.

The following table gives a synoptical equivalent value of different kinds of food; albumen representing the flesh-forming principle, and unazotized matter the fat-forming.—*Playfair.*

	ALBUMEN.	UNAZOTIZED MATTER.
Peas	29	51½
Beans	31	52
Lentils	33	48
Potatoes	2	24½
Oats	10½	68
Barley meal	14	68
Hay	8	68½
Turnips	1	9
Carrots	1½	8½

From the above table we may see, why pigs, fed upon potatoes and barley-meal, soon fatten and keep in health; whereas, when supplied with potatoes only, they become fat but are unhealthy. It will also teach us that the milk of cows, from which cheese is to be made, would be benefitted by mixing their food with steeped peas and beans.

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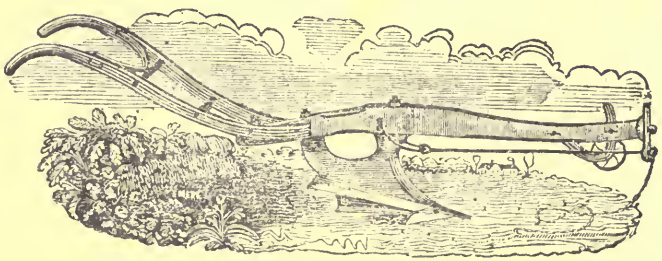

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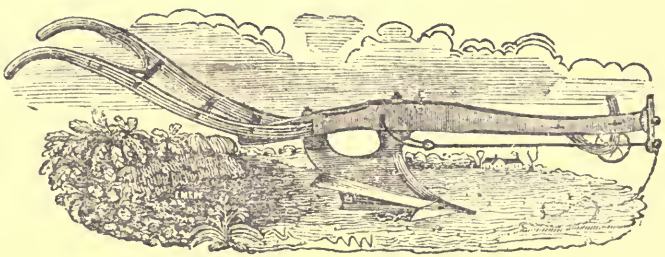

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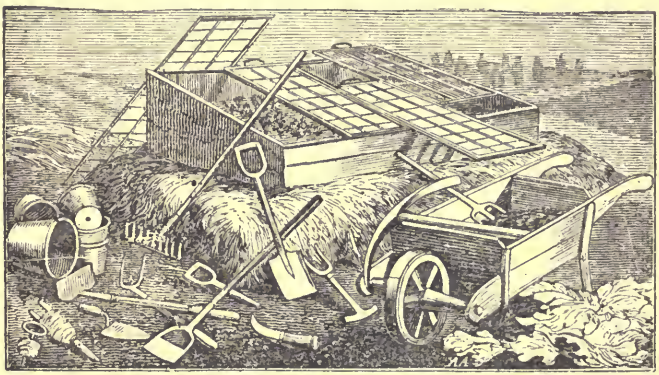

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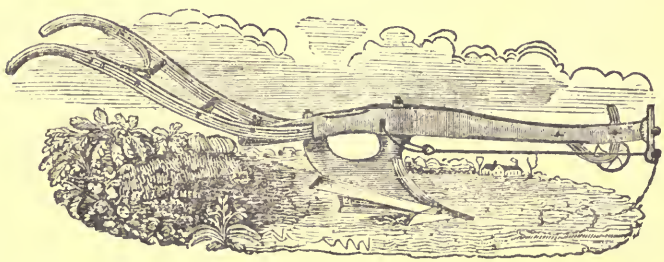

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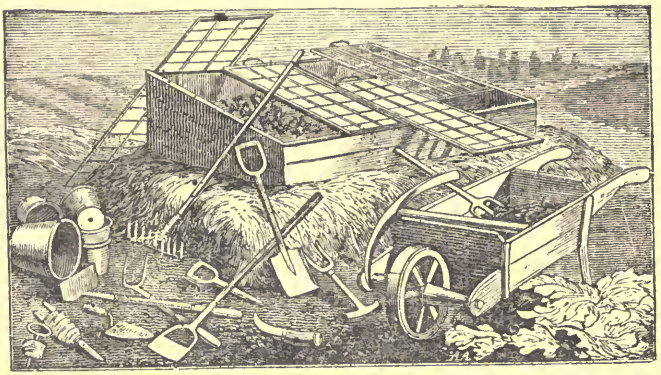

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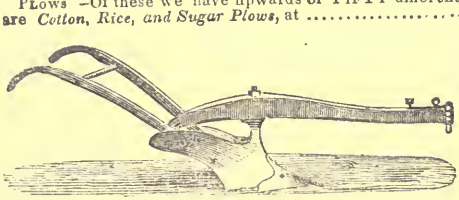

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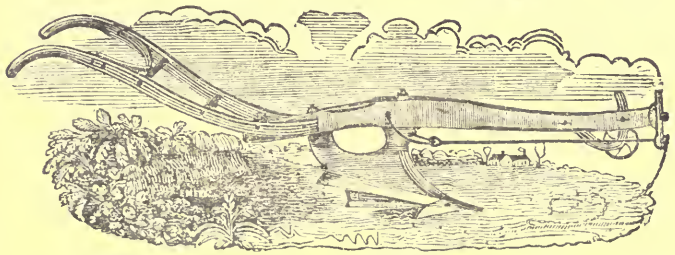

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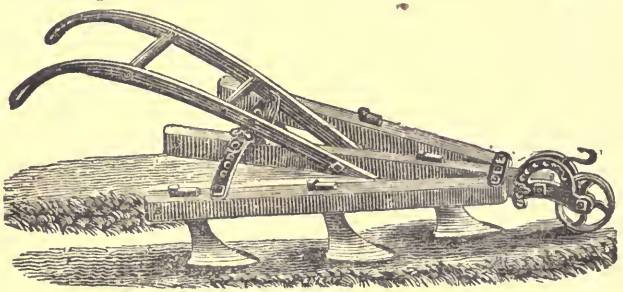

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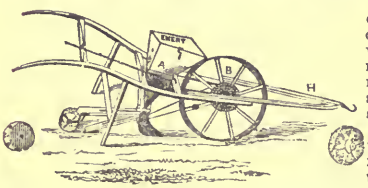

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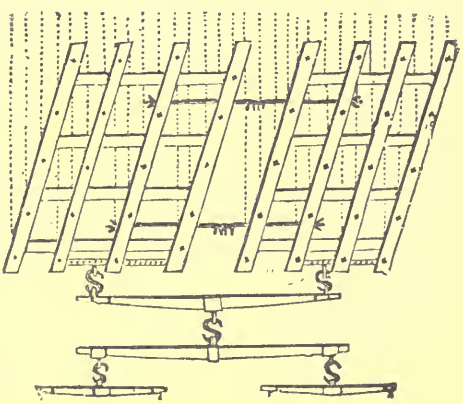

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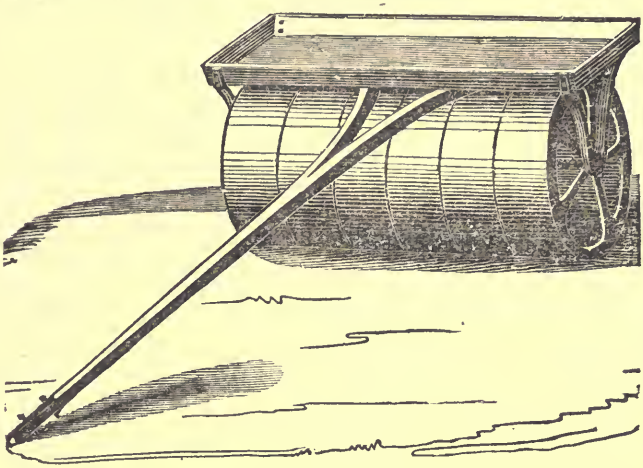

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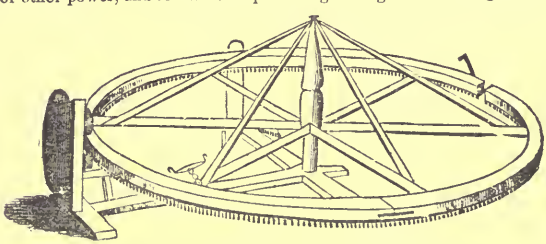

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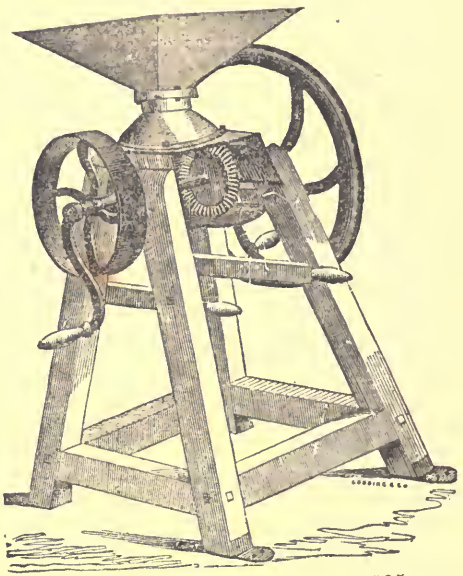

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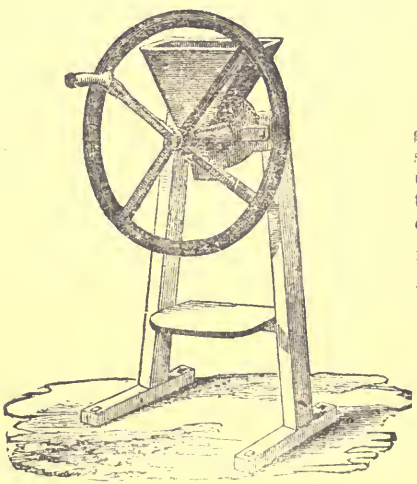

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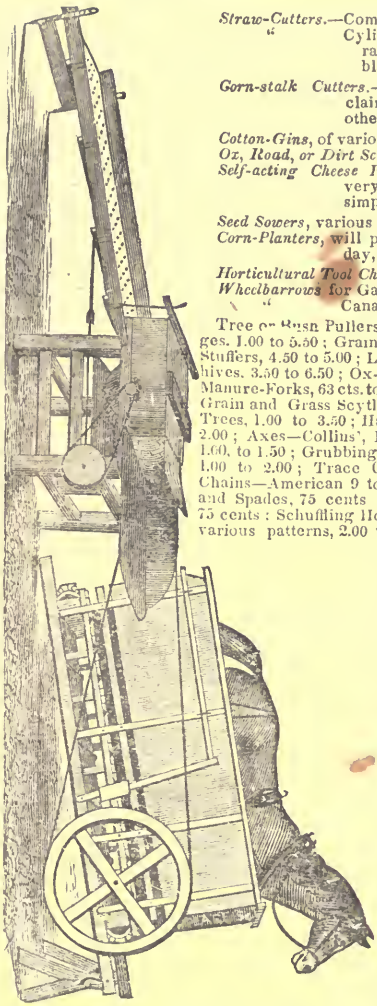

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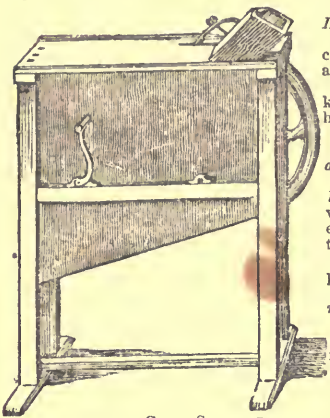

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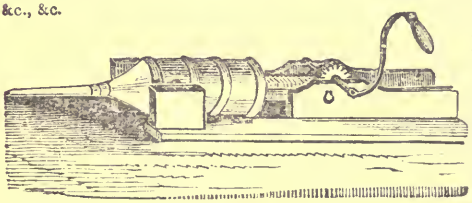

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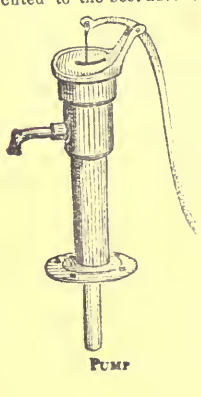

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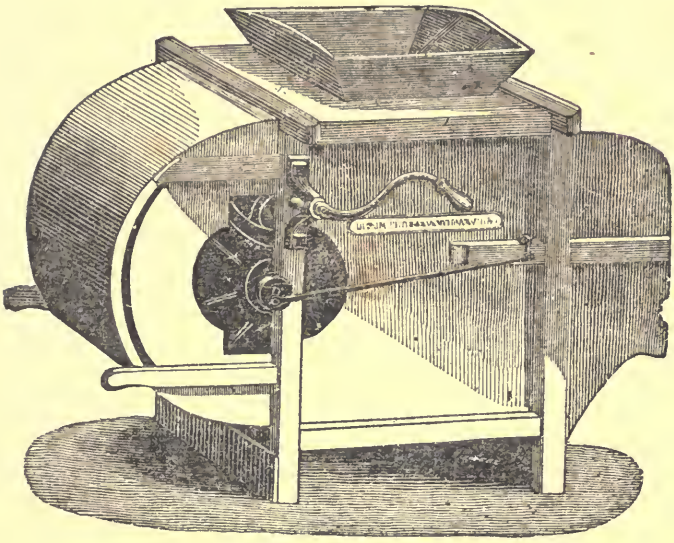

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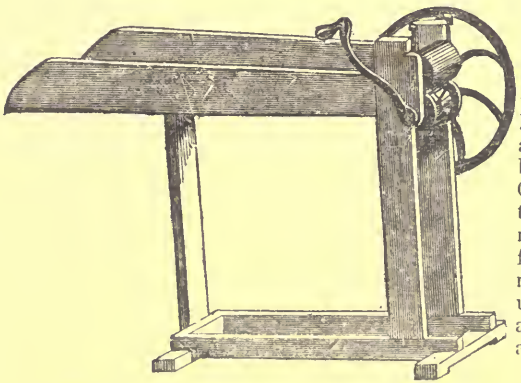

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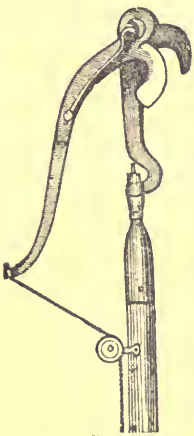

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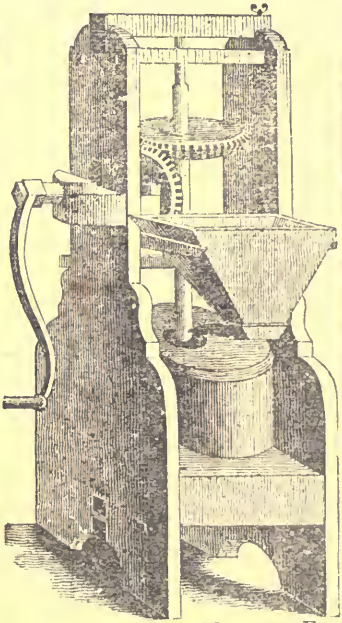

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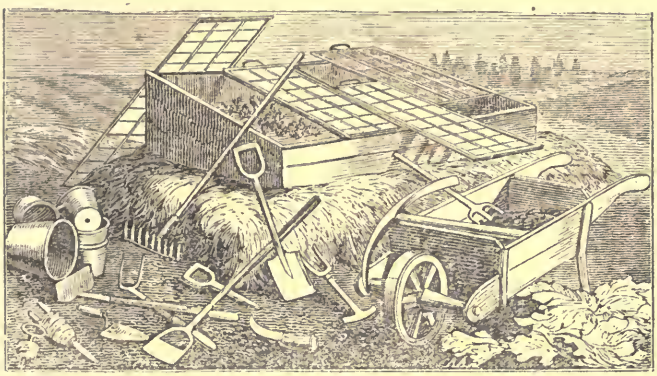

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Fig. 1. denotes a small pair of shears which are very useful for trimming box trees and bushes, as well as for many other purposes.

Fig. 2. shows another pair of pruning shears with wooden handles, which are handsomely and finely made; they are very convenient for trimming shrubbery, &c., that is too large to be cut by the scissors or hand shears.

Fig 3. represents a pair of iron-handled shears, designed for pruning raspberries, rose bushes, &c. They have a sliding centre and spring, and make a perfectly smooth cut.

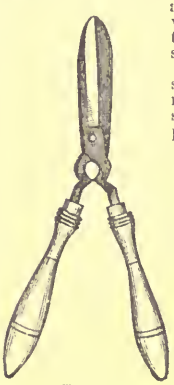

Fig. 1.

Fig. 3.

Fig. 4.

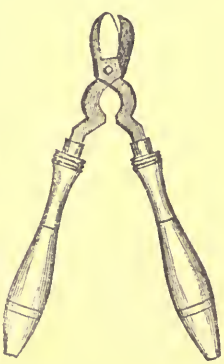

Fig. 2.

Fig. 5. represents a Triangular Hoe; Fig. 6, a Garden Rake; Fig. 7, a Pruning Saw and Chisel; Fig. 8, a Garden Syringe; Fig. 9, a Fork-backed Hoe; Fig. 10, a Fruit Gatherer; Fig. 11, a Garden Trowel; Fig. 12, a light Garden Spade.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

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